AUG 6 1970

NATIONAL BUREAU OF STANDARDS REPORT

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METALLURGICAL EXAMINATION AND MECHANICAL TESTS OF MATERIAL FROM THE POINT PLEASANT, W. VA. BRIDGE

8/6/70

Part 7

Examination Of Fractured Rivets In
The Bearing Box of Joint U13N
(Revised)

To

Bureau of Public Roads
Federal Highway Administration
Department of Transportation

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic and Molecular Physics—Radio Physics [2]—Radio Engineering [2]—Time and Frequency [2]—Astrophysics [2]—Cryogenics.[2]

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

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THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

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THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System, and provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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Part 7

Examination Of Fractured Rivets In
The Bearing Box of Joint U13N
(Revised)

By
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Engineering Metallurgy Section
Metallurgy Division

To
Bureau of Public Roads
Federal Highway Administration
Department of Transportation

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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Examination of Fractured Rivets in the Bearing Box of Joint U13N of the Point Pleasant, W. Va. Bridge

Introduction: Rivets in the bearing box of joint U13N of the Point Pleasant Bridge were found to be fractured. Two sections each containing fractured rivets were cut from the bearing box and the rivets were examined visually and metallographically as requested by the submitting agency. One of the sections identified as U13NN was comprised of a segment of the U13NN main channel and a segment of the mating gusset plate. The other section identified as U13NS was comprised of a segment of the U13NS main channel and a segment of its mating gusset plate. The U13NN section was originally attached by the rivets to the north flange of the west diaphragm channel in the box and the U13NS section was originally attached to the south flange. Flange sections were not available for examination. Figure 1 shows the section cut from U13NN and Figure 2 the section from U13NS; with the rivet remnants of both in place, as received. For report purposes the rivets were labeled U13NN-A, B, C, and D and U13NS-A, B, and C. White dots on the section gusset plates are identification markings made by BPR.

Visual Examination: As received, both sections were twisted and rivet heads were broken-off flush with the outside face of the gusset plates (see Figures 1 and 2). The gusset plates were deformed to a greater extent than their complementary channels. It was evident from the twisted shape of the channels and gusset plates comprising the sections that the rivets could have been subjected to a combination of tension, bending and shear stresses.

The rivet remnants were removed from the rivet holes and are shown free-standing in Figure 3 in the relative positions they occupied in the sections before their removal. As shown in Figure 3, the halves of the rivet shanks adjacent to the fracture surfaces are slanted and, in general, the peripheries of the fracture surfaces are elliptical. The arrows in Figure 3 point in the probable directions in which the rivet shanks were stressed before fracture occurred. Stress in a given rivet was considered to have been applied parallel to the major axis of the elliptical periphery of the fracture surface and/or in the direction of the slant in the rivet shank.

No appreciable corrosion was found in rivet holes, on the channel web, or on the gusset plate surfaces immediately adjacent to the rivet holes. Pitting corrosion was observed on the channel and gusset plate faying surfaces of the U13NN section and on the outside surface of the U13NS gusset plate. The pitted areas were remote in their relation to rivet location. No deformation was observed on the rims of the rivet holes. The rivet shanks were indented. It appears that the indentation occurred during driving of the rivets. No evidence of preexisting cracks was found. Rivets in both sets necked adjacent to the fracture surfaces and rivet shanks were bent. It appears that this deformation occurred as a result of the stressing to which the rivets were subjected.

Metallographic Examination: Specimens containing the fracture surfaces were removed from rivets No. U13NN-A, U13NN-D and U13NS-C for metallographic examination. No evidence of stress corrosion cracking was observed in the microstructures.

The microstructures of etched sections of these rivets are shown in Figures 4 through 7. Figures 4a and 4b show normal hot-worked microstructures in areas remote from the fracture surfaces of rivets U13NN-D and U13NS-C, respectively. Figure 4c shows decarburization in peripheral areas of the shank of rivet U13NN-A. Peripheral decarburization was present on the shanks of all three rivets.

Figures 5, 6, and 7 show the fracture profiles for rivets U13NN-A, U13NN-D and U13NS-C, respectively. Cleavage (transgranular fracture) predominated in the fracture profile of all three rivets immediately adjacent to the fracture origin. Discontinuous cleavage (cleavage plus shear of the grains) was present in the fracture profiles at some distance from the origin. Shear predominated at the fracture mid-path.

Discussion and Conclusions: No corrosion that could have contributed to failure was observed on the rivets. There was no evidence of preexisting cracks.

Fracture of the rivets examined was initiated in decarburized zones where the resistance to separation (cleavage) was lower than the resistance to yielding. Plastic deformation evident at the fracture mid-path was not present immediately adjacent to the fracture origin. General yielding of the rivets occurred before complete fracture. Shear predominated in the fracture of all three rivets examined.

Strain-hardening of the rivets occurred as stress was applied. In the process of fracturing, the energy absorbed was evidently high and the fracture stress was higher than the ultimate strength of the material. Accordingly, the fracture behavior could be characterized as being ductile. It appears that fracture of the rivets resulted from overloading of the steel in the plastic range. The appearance of the fracture profiles indicates a relatively high strain rate.

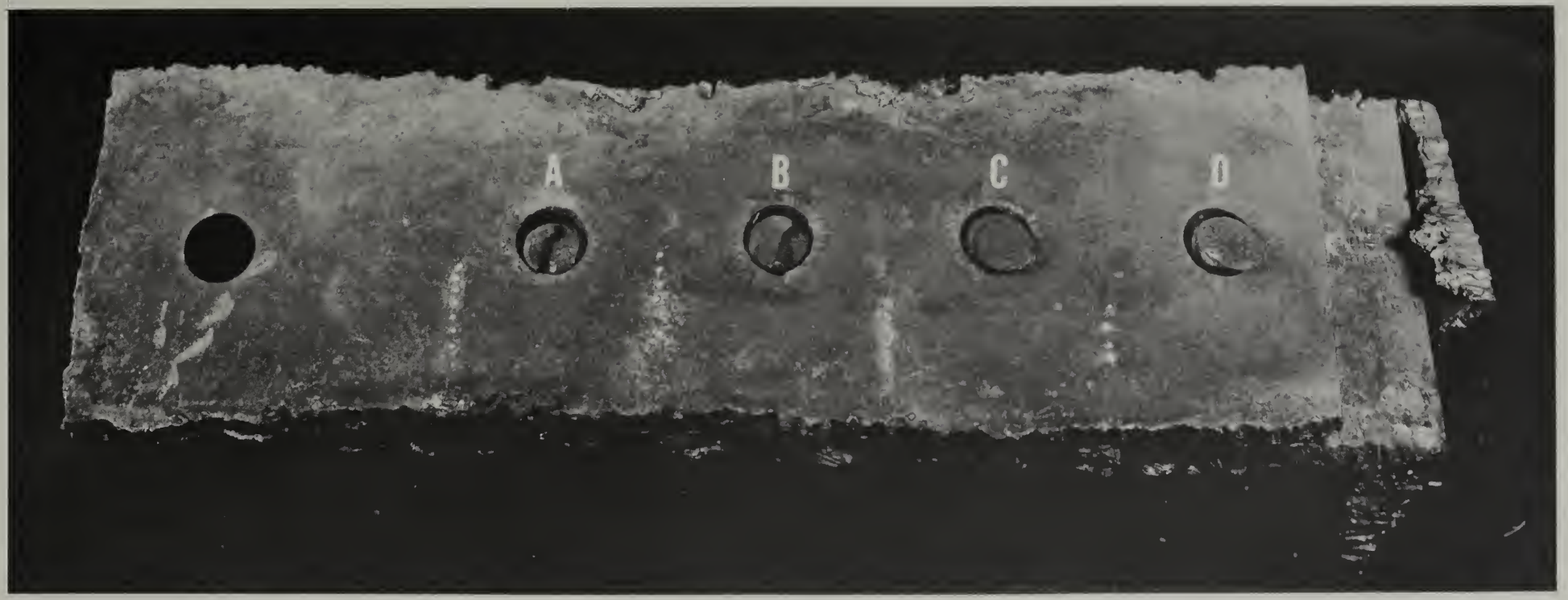


Figure 1. Section of U13NN member showing fractured rivets in place. Rivets were labeled A, B, C and D for report purposes. White dots on gusset plate are BRP markings. Approx. X 1/2.

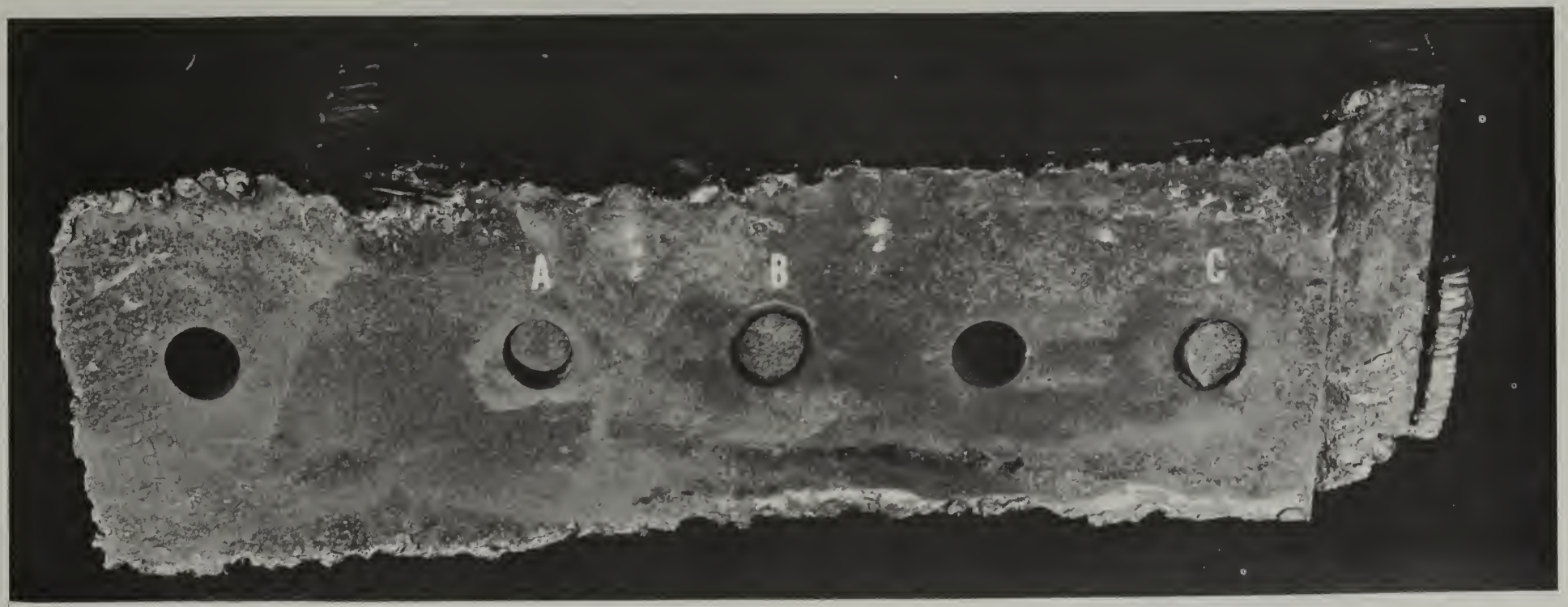
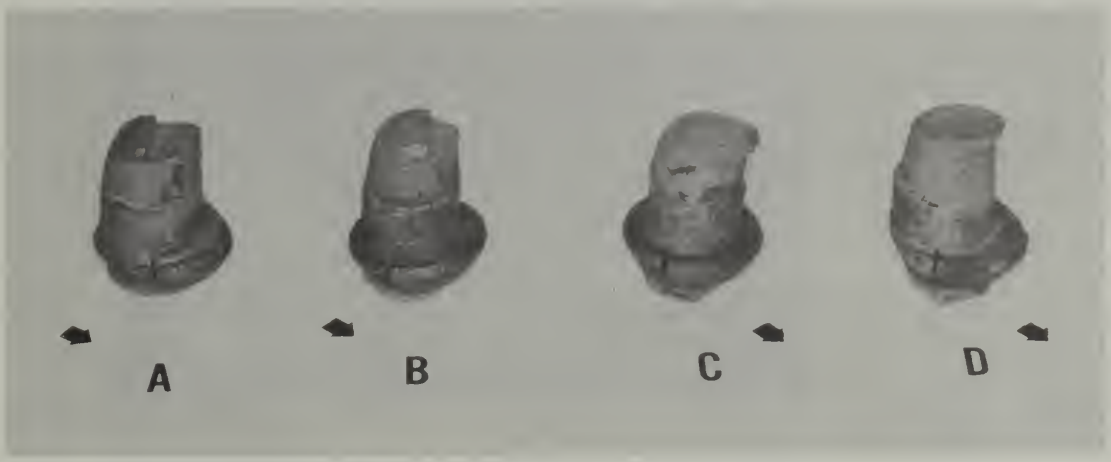


Figure 2. Section of U13NS member showing fractured rivets in place. Rivets in this section were labeled A, B and C for report purposes. White dots on gusset plate are BPR markings. Approx. X 1/2.



a

b

Figure 3. Rivets are shown free-standing in their relative positions prior to removal from their respective sections. Arrows point to the probable directions in which the rivets were stressed. X 1/2

a. Rivets from section U13NN.

b. Rivets from section U13NS.

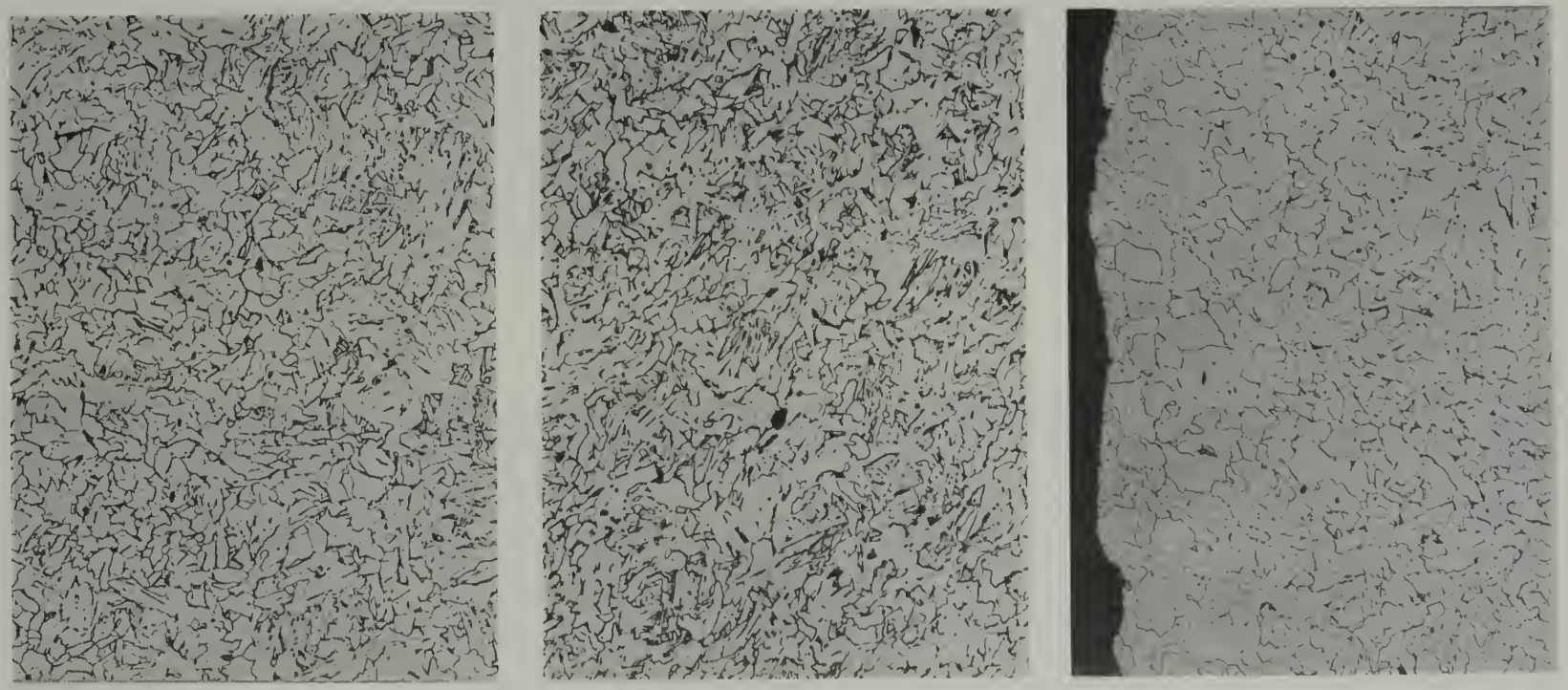


Figure 4. Microstructures in rivet shanks at approximately 1/2 inch from fracture surface. Etched with 5% Nital. X 100.

a. Normal hot worked structure in U13NN-D.

b. Normal hot worked structure in U13NS-C.

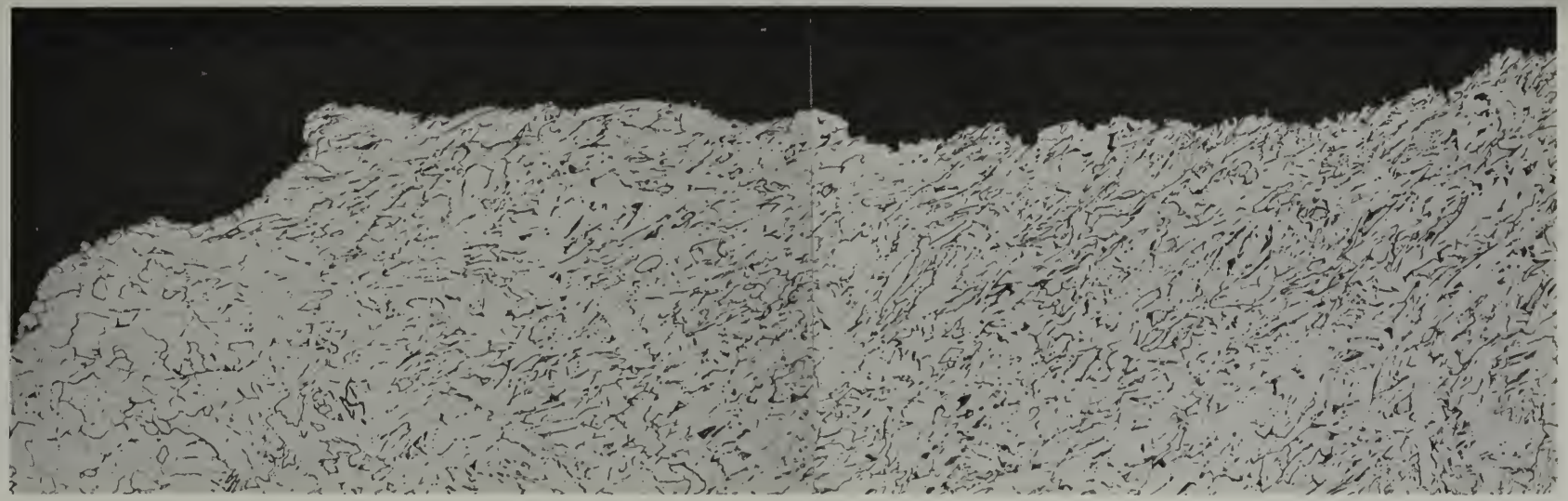
c. Decarburization at periphery of U13NN-D.

a

b

Figure 5. Fracture profile of rivet U13NN-A. Etched with 5% Nital. X 100.

a. At origin.
b. At fracture mid-path.

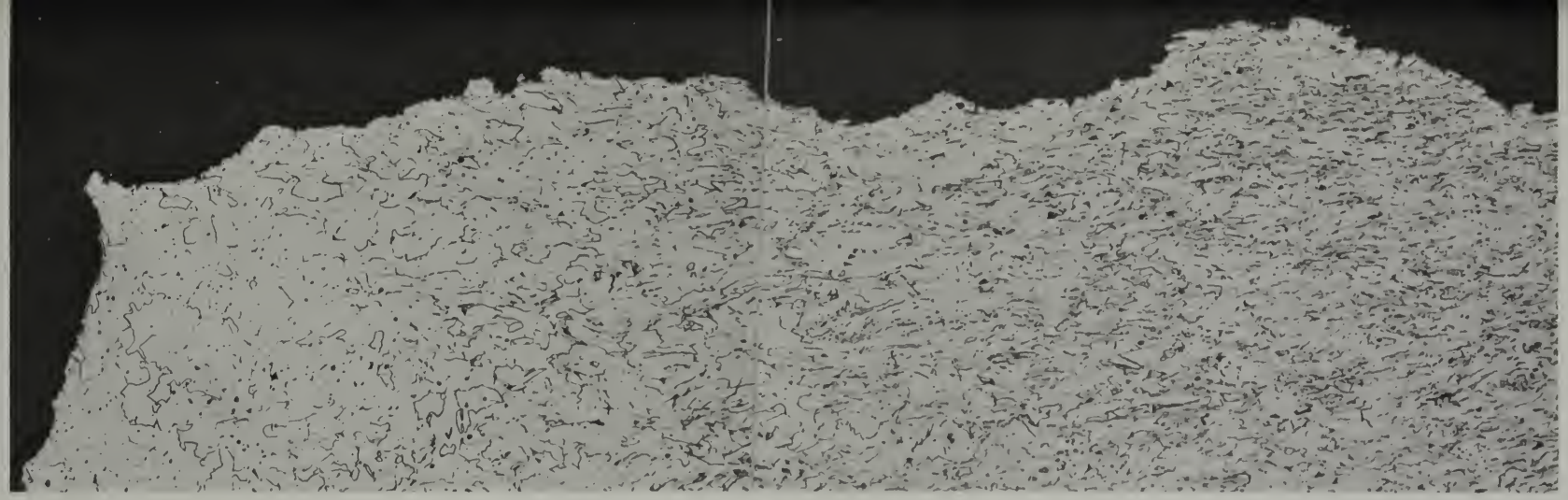


a

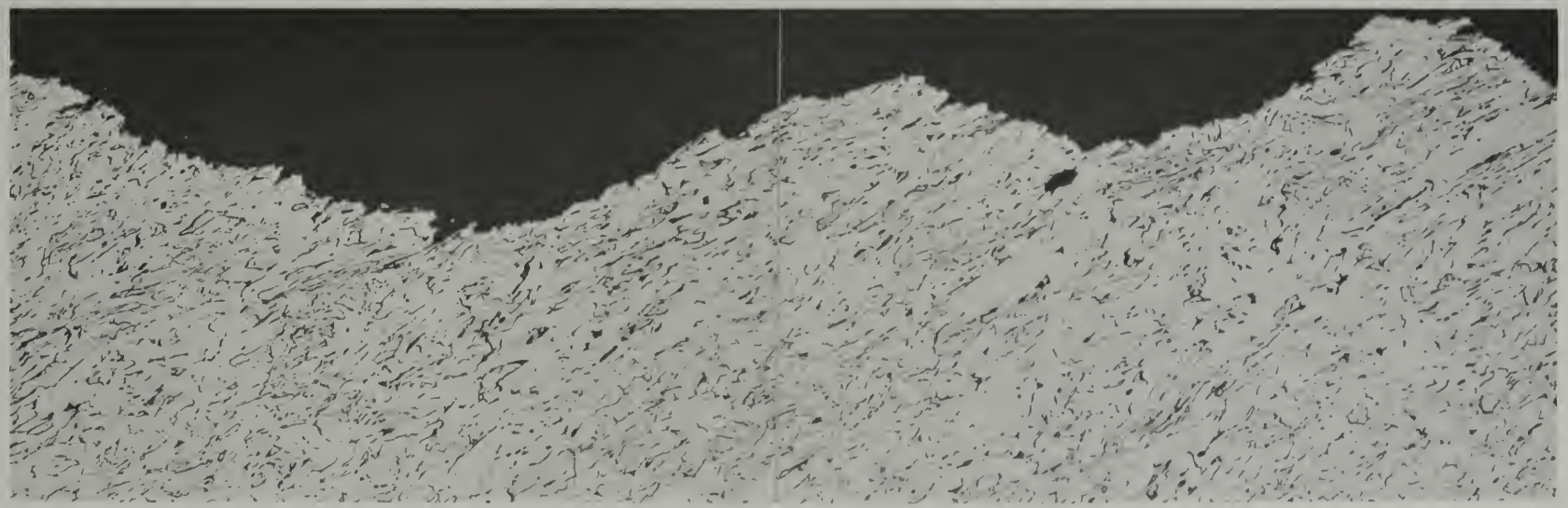
b

Figure 6. Fracture profile of rivet U13NN-D. Etched with 5% Nital. X 100.

a. At origin.
b. At fracture mid-path.



a



b

Figure 7. Fracture profile of rivet U13NS-C. Etched with 5% Nital. X 100.

a. At origin.
b. At fracture mid-path.

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